ACCOMMODATING THERMAL EXPANSION IN PIPING SYSTEMS

MECHANICAL EXPANSION DEVICES
When pipe changes temperature there is always a change in the pipe length that must be accommodated.

Either by:

- The inherent flexibility of the piping arrangement
- Engineered pipe expansion loops
- Mechanical devices
Types of Mechanical Devices

Axial Type:

- Used in straight runs of pipe that have no offsets or bends.
- Usually in tunnels, trenches, direct buried or at grade level.
- Types:
  - Packed Slip Type Expansion Joints
  - Bellows Type Expansion Joints
ATS TP2 Single Slip Expansion Joint
Typical Externally Pressurized Bellows Expansion Joint
Types of Mechanical Devices

Nonlinear Type:

- Require a change in direction; i.e. an offset or a change in elevation.
- Ideal for use in overhead pipe racks.
- Types:
  - Flexible Ball Joints
  - Hinge, Gimbal or Tied Bellows Joints
Typical Ball Joint Linkage:
Design of Pipe Runs With Axial Expansion Devices.

- Only axial movement can be accommodated. Pipe guides, anchors and expansion joints must be arranged such that only axial movement occurs.

- Other types of movement (lateral and/or angular) may cause binding of the slip or excess strain in a bellows.
Packed Slip Type Expansion Joints

Advantages

- Fabricated from materials similar to the pipe line.
- Rugged construction.
- No catastrophic failure mode.
- Allows for safe packing injection under full line pressure.
- In the event that a leak occurs there is no need to shut the system down for repairs.
Packed Slip Type Expansion Joints

Disadvantages

- Must be located to allow access.
- May require occasional addition of injectable packing.
Typical Expansion Joint Installation:
Expansion Joints installed in a long straight pipe run
Bellows Type Expansion Joints

Advantages

- Do not require access; i.e. can be direct buried, however a telltale device is recommended.
- No maintenance is required.
Bellows Type Expansion Joints

- **No** in place maintenance or repair can be performed. It must be replaced if damaged.
- When failure occurs the system must be shut down.
- Chance of personal and/or property damage when failure occurs.
- Installer can easily misuse joints when correcting for pipe misalignment.
Pipe Anchors

Types of Pipe Anchors

- Main Anchors
- Intermediate Anchors
Pipe Anchors

Anchors Loads

Main Anchors
- Pressure Thrust
- Packing Friction Force or Spring Rate Loads
- Pipe Support/Guide Friction Loads

Intermediate Anchors
- Packing Friction Force or Spring Rate Loads
- Pipe Support/Guide Friction Loads
Placement of Anchors

Anchor placement is different when using mechanical devices, than when relying on natural flexibility.

**Mechanical Devices - Axial Movement:**
Anchors should be placed at changes in pipe direction.

**Natural Flexibility:**
Anchors are not normally placed at 90° offsets, and must be strategically located.
Location of Anchors in Pipe Runs with Axial Expansion Joints

- Pipe lines should be divided into segments, separated by anchors.
- All end points must be anchored.
- All changes in direction must be anchored.
- Intermediate anchors should be used in long runs to separate expansion joints. Only one slip joint should be located between two anchor points.
Anchors Loads

Pressure Thrust Loads:

Pressure Thrust loads are the result of the system pressure acting on the effective cross sectional area of the expansion joint.

\[ F_p = P \times A \]

Note: The thrust areas for Packed Expansion Joints is different than that of Bellows Joints.
Anchors Loads

Friction Force or Spring Rate Loads:

Packed Expansion Joints:

1,000 lbs./inch of Nominal Pipe Diameter.

Bellows Joints:

Listed Spring Rate x Calculated Compression
Support/Guide Friction Loads:

Support/Guide Friction Loads are published per 100 ft. of pipe for various sizes. These loads are based on industry standard support spacing.

Note: If low friction supports & guides are used the friction loads can be reduced by as much as 50%.
## Typical Anchors Loads

<table>
<thead>
<tr>
<th>Pipe Size</th>
<th>Packed Expansion Joint</th>
<th>Bellows Expansion Joint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>150 lb.</td>
<td>300 lb.</td>
</tr>
<tr>
<td>6&quot;</td>
<td>11,175</td>
<td>16,350</td>
</tr>
<tr>
<td>12&quot;</td>
<td>31,155</td>
<td>50,310</td>
</tr>
</tbody>
</table>
ATS Pre-Engineered Pipe Anchors:

6" Fig. 702-STD-B-1

16" Fig. 701-SPC-B-2
w/6" Branch Connection
Anchor installed adjacent to an Expansion Joint
Improper Anchor Arrangements

Expansion Joint w/Anchor Base

Installation with offset

Anchor
Improper Anchor Arrangements

Expansion Joint w/Anchor Base

Expansion Joint Installed with Misalignment
Improper Anchor Arrangements

Anchored Expansion Joints
Pipe Anchors

Improper anchoring can result in over stressed conditions and excessively high anchor loads.

10 ft. of 10" pipe installed at 70° F in a straight run between two anchors will at 400° F:

- Try to expand approximately 1/4" in length.
- Result in anchor loads in excess of 790,000 lbs.
Pipe Guides

The location of both Primary and Secondary Guides is dependent on the type of expansion joint that is being used.
Pipe Guides

For Packed Slip Type Expansion Joints with Anchor Bases:

- The Primary Guide should be located within a distance of 1 foot for each inch of nominal pipe diameter.

- The first two Intermediate Guides should be located in accordance with industry standards.

- Beyond the first two Intermediate Guides the spacing can be increased to 3 times the standard; and this should continue up to a point equal to 75% of the pipe run length.

- A minimum of two (2) guides should be used on each slip end.
Pipe Guides

For Packed Single Slip Expansion Joints w/o Anchor Bases where the Slip Joint is Located more than two (2) Support Points Away from an Anchor:

✓ For sizes 1½" to 4" inclusive; the Primary Guide should be located no more than six (6) pipe diameters from each end of the slip joint.
✓ For sizes 5" to 24" inclusive; the Primary Guide should be located no more than three (3) pipe diameters from each end of the slip joint.
✓ Beyond the Primary Guides; the guide lines for expansion joints with anchor bases should be followed.
Pipe Guides

The guiding requirements for bellows joints are more stringent than for packed expansion joints.

For bellows expansion joints:

- The primary guide should be located within a distance of four (4) pipe diameters from the end of the bellows.

- The second guide should be located approximately 14 pipe diameters from the primary guide.

- Beyond the first two guides, the spacing should follow industry recommended standards.
Pipe Guides

ATS Fig. 101-W
Low Friction Pipe Guide

ATS Model GA
Radial Pipe Guide
Design of Pipe Runs With Nonlinear Expansion Devices.

In many cases piping systems include offsets or changes in direction. In the event that these offsets are too small to be effective in reducing system stresses; Nonlinear expansion devices can be used.

Nonlinear expansion devices such as ball joints can accommodate movements in multiple directions.
Ball Joints:

- Ball joints are available in sizes ranging from 3/4" through 30" NPS

- Ball joint flex angles range from 15 degrees for standard designs to as high as 30 degrees for Hi-Flex designs.

- Available end connections:
  - Butt Weld
  - Socket Weld
  - Threaded
  - Flanged
  - Victaulic
ATS Series P2 & S2 Ball Joints:
The Condensed History of Ball Joints

19?? to Present
Early style ball joints were designed using soft seals and a bolted retainer flange. Leakage was contained by tightening the retainer flange bolts to compress the seals against the spherical ball. Over tightening the retainer flange bolts resulted in increased torque and in some cases the ball locking up during service.

Early style ball joints were designed using soft seals and a bolted retainer flange. Leakage was contained by tightening the retainer flange bolts to compress the seals against the spherical ball.
Soft seated ball joints are still available; but are only recommended for low pressure/temperature applications or services which require a high degree of cleanliness.

Typical applications include:

- Potable water.
- Jet fuel transport systems, after the filters.
- Clean steam systems such as those used in hospitals or some manufacturing processes.
- Gas systems (oxygen, nitrogen, etc.)
ATS Series P1/S1 - 2nd Generation Ball Joints:

In 1979 ATS introduced the first packed ball joints designed for packing injection under full line pressure. The original design of the packed ball joint was developed using many of the same parts as were used for the soft seated design, including the bolted retainer flange. The injectable packing used, was the same packing that ATS had been using for years with our Thermal Pak TP2 Slip Type Expansion Joints.

With this design; ductile iron rings replaced the soft seats and served to center the ball within the body of the joints; and injectable packing was used to provide the required sealing.

The development of the packed ball joint significantly extended the pressure temperature capabilities of the joints in addition to providing more dependable leak free performance.
ATS Series P1/S1 - 2nd Generation Ball Joints:

- Ductile iron seal rings
- Graphite impregnated containment seals
- "HPI" flake graphite injectable packing
- Packing cylinder and plunger
- Bolted retainer flange

ATS Series P1 Ball Joint
ATS Series P2/S2 - 3rd Generation Ball Joints:

Realizing that the need to adjust the retainer flange to ensure proper sealing was no longer necessary; in 1985 ATS developed the Series P2/S2 design which included an integral socket retainer flange. With this design the bulky, bolted retainer flanges or retainer caps were eliminated in favor of a more compact welded design.

"The latest in Ball Joint Technology"
ATS Series P2 Ball Joint

Rugged 2" diameter packing cylinders

Integral welded socket and retainer
ATS Series P2 Ball Joint

Hard chrome plated spherical ball

Ductile iron seal rings

"HPI" Flake graphite injectable packing

Graphite impregnated containment seals
ATS Series P2/S2 - 3rd Generation Ball Joints:

ATS Series P2/S2 Thermal Pak Ball Joints offer the following advantages over the older bolted retainer flange design:

1. Eliminates the in-service field error of over tightening the retainer flange bolting which greatly increases the flex torque and may cause "freezing" of the ball within the socket.

2. To contain leakage, it is best to inject packing vs. the tightening of retainer flange bolting, since packing injection can be controlled to minimize the flex torque values and produce a more positive containment method.

3. Eliminates the need for stainless steel bolting when the ball joint is installed in a corrosive environment and/or must handle a corrosive fluid.

4. The integral retainer flange design results in a more compact, lighter ball joint that is easier to install and insulate.

"The latest in Ball Joint Technology"
8 Solid reasons why ATS Ball Joints offer major advantages over other methods for handling pipe movement:

- Ball joint systems offer cost saving advantages by reducing the quantity and size of anchors and guides required in the piping system.
- Ball joint systems permit pipe movement in two or more planes simultaneously.
- Ball joints provide more movement in less space, taking full advantage of available space.
- ATS ball joints are designed to withstand high shock and vibration loads.
- Ball joints are designed to allow pivotal movement in addition to the ability to flex angularity and are ideal for accommodating twisting movements and torsional loads.
- ATS ball joints are designed for low maintenance service in a wide range of operating conditions.
- The ball joint system reduces end thrust after the initial force required to flex the ball joints is exerted.
- **ATS Series P2 ball joints are designed for packing injection under full line pressure; thus assuring maximum reliability for uninterrupted service.**
In the event that a leak occurs, simply remove one of the packing plungers, drop in a packing plug and then reinstall the packing plunger.
Where to use Ball Joint Linkages:

- Any place where expansion stresses are too high & a natural offset exists (L-Bend or Z-Bend).
- Any systems where the anchor loads must be minimized.
- Systems subject to large displacements; such as seismic applications and well heads.
Advantages of using Ball Joint Linkages to accommodate expansion in Piping Systems:

- Lower anchor loads than those associated with either bellows or slip type expansion joints.
- Guiding requirements are far less stringent.
- They accommodate multi-plane as well as pivotal and twisting pipe movements.
- Due to their construction; the internal pressure tends to aid in sealing and they are therefore less likely to develop leaks in service.
Typical Ball Joint Linkage Arrangements:

Linear Pipe Expansion or Contraction

Pipe Alignment (Tank Settling)
More Ball Joint Linkage Arrangements:

Angular Flexing

Pivotal Motion
More Ball Joint Linkage Arrangements:

3 Ball Joint Linkage

Knee Linkage
2 Ball Joints Linkages:

Ball joint linkages can accommodate movement in multiple directions.
3 Ball Joint Linkage
QUESTIONS ? ? ? ?